

CHAPTER 13.1 – HOMEOSTASIS

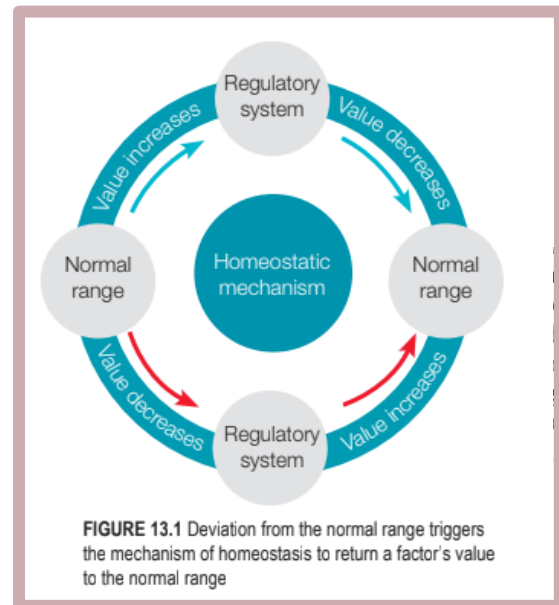
Homeostasis

- Δ Homeostasis is the regulation of physical and chemical factors of the internal environment within normal ranges for the cell to function in optimum conditions

Physical and chemical factors of the internal environment

- » The physical factors that need to be regulated are temperature, osmotic blood pressure and blood pressure
- » The chemicals that need to be regulated are pH value, the concentration of minerals and blood sugar concentrations
- » Any deviation from the normal range triggers the homeostatic mechanism which involves negative feedback
- » Homeostasis regulates the internal environment in order for it to be in a constant state although the external environment changes a lot
- » This ensures that cell activity continues to function at the optimum level
- » In homeostasis,
 - 1) A factor that exceeds the normal range is brought down to the normal range

- 2) A factor that falls below the normal range is increased to the normal range



The organ system involved in maintaining an optimal internal environment

- ⊞ Body temperature is regulated by the integumentary system (skin and sweat glands), nervous system, circulatory system, muscle system and endocrine system
- ⊞ Blood sugar levels are regulated by the endocrine gland, circulatory system and digestive system
- ⊞ The partial pressure of carbon dioxide in the blood is regulated by the respiratory system, circulatory system and nervous system

- ⊡ Blood pressure is regulated by the circulatory system and nervous system

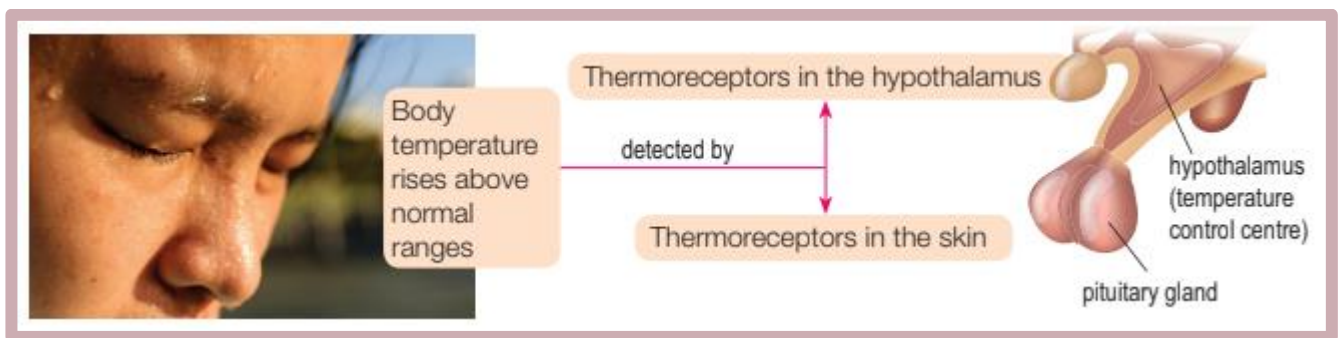
Regulating body temperature

- Maintaining the body temperature at a fixed range is important so that cell metabolism reactions that are

catalysed by enzymes occur at optimum levels

- Temperatures that are too high will denature enzymes, while temperatures that are too low will slow down the metabolic activity of the cell, and prevent it from carrying out cell processes
- These changes in body temperature are detected by the thermoreceptors in the skin and the hypothalamus

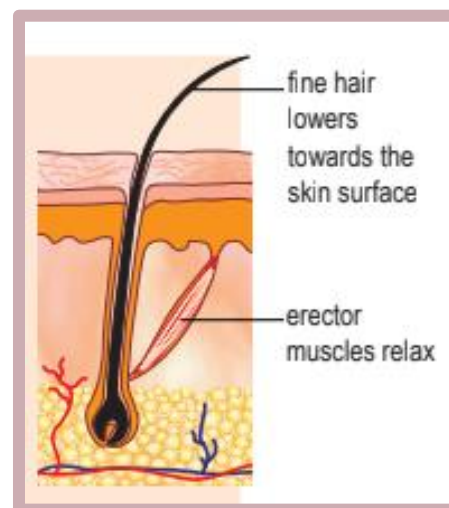
Body temperature regulation when temperature increases



REGULATION OF BODY TEMPERATURE BY EFFECTORS THROUGH PHYSICAL METHODS

ERECTOR MUSCLES

- ↘ Erector muscles are less stimulated so they do not constrict and the fine hair will lower towards the skin surface
- ↘ As a result, a thin layer of air is trapped between the fine hair
- ↘ Heat can be released quickly



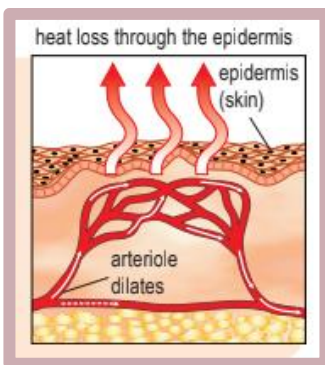
SKELETAL MUSCLES

- ◇ Skeletal muscles contract and relax less
- ◇ The body does not shiver



ARTERIOLES

- Arterioles in the skin dilate (vasodilation) to allow more blood to flow to the skin surface
- More heat is lost to the external environment through radiation



SWEAT GLANDS

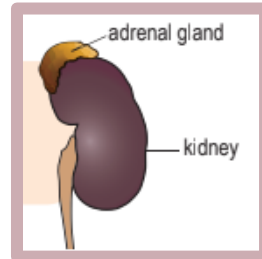
- The sweat glands are stimulated to produce more sweat
- Heat is absorbed to evaporate sweat, and this cools the skin



REGULATION OF BODY TEMPERATURE BY EFFECTORS THROUGH CHEMICAL METHODS

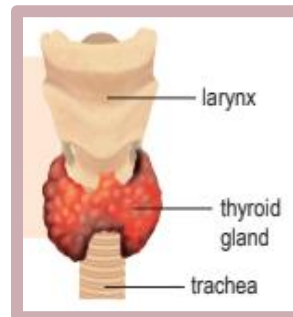
ADRENAL GLANDS

- ⊕ The adrenal glands are less stimulated to secrete adrenaline
- ⊕ Metabolic rate decreases

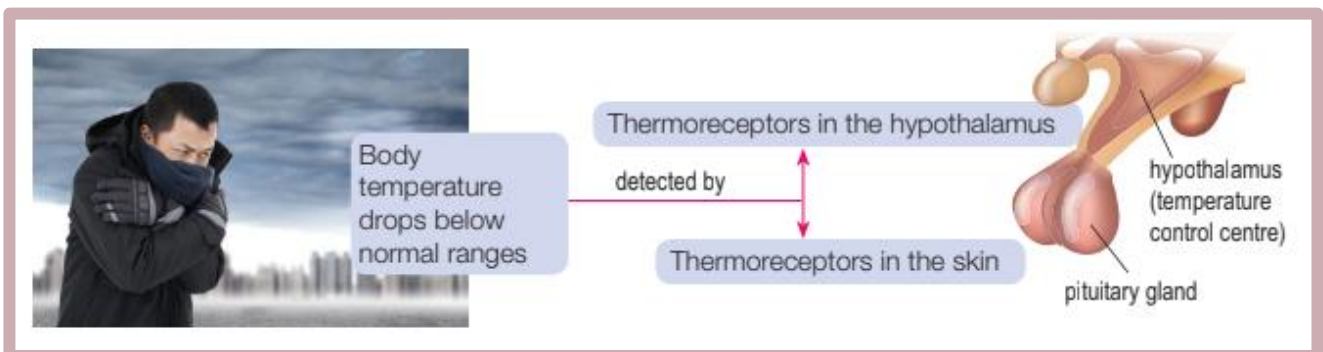


THYROID GLANDS

- ⊖ The thyroid gland is not stimulated and the secretion of thyroxine is reduced
- ⊖ Metabolic rate decreases
- ⊖ No excess heat is generated



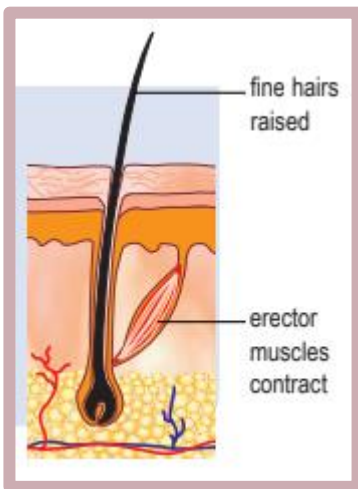
Body temperature regulation when temperature decreases



REGULATION OF BODY TEMPERATURE BY EFFECTORS THROUGH PHYSICAL METHODS

ERECTOR MUSCLES

- ◇ Erector muscles are stimulated so they contract, causing fine hair to stand erect
- ◇ A thick layer of air trapped between the fine hairs acts as an insulator that prevents loss of heat from the skin



SKELETAL MUSCLES

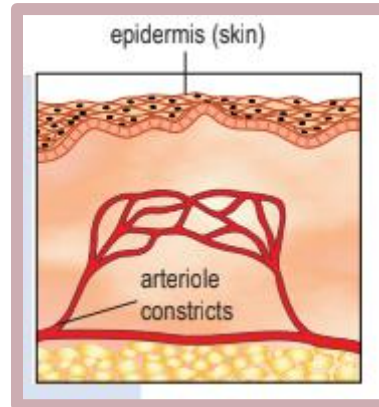
- » Skeletal muscles will contract and relax so the body will shiver
- » This generates heat which in turn raises the body temperature because the constriction of muscles requires energy



ARTERIOLES

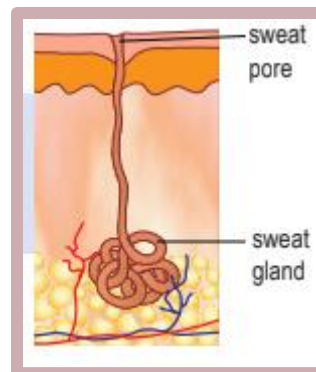
- ⊕ Arterioles in the skin are stimulated to constrict (vasoconstriction)

- ⊕ The result is less blood flow to the surface of the skin
- ⊕ With that, less heat is lost to the external environment through radiation



SWEAT GLAND

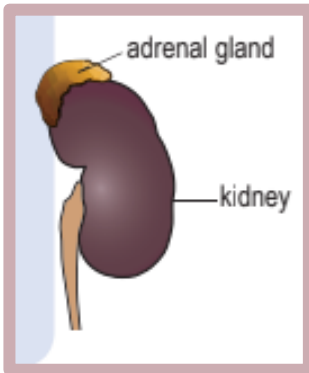
- ⇒ The sweat gland is not stimulated
- ⇒ Sweating does not happen



REGULATION OF BODY TEMPERATURE BY EFFECTORS THROUGH CHEMICAL METHODS

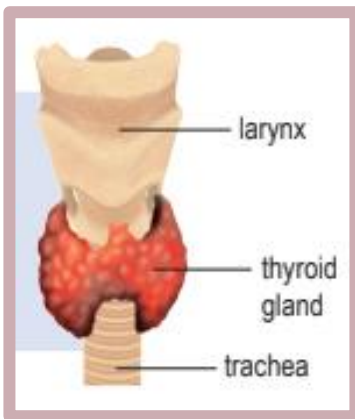
ADRENAL GLANDS

- ⊞ The adrenal glands are stimulated to secrete more adrenaline
- ⊞ This hormone speeds up the conversion of glycogen to glucose
- ⊞ Metabolic rate increases
- ⊞ The oxidation of glucose releases heat to warm the body



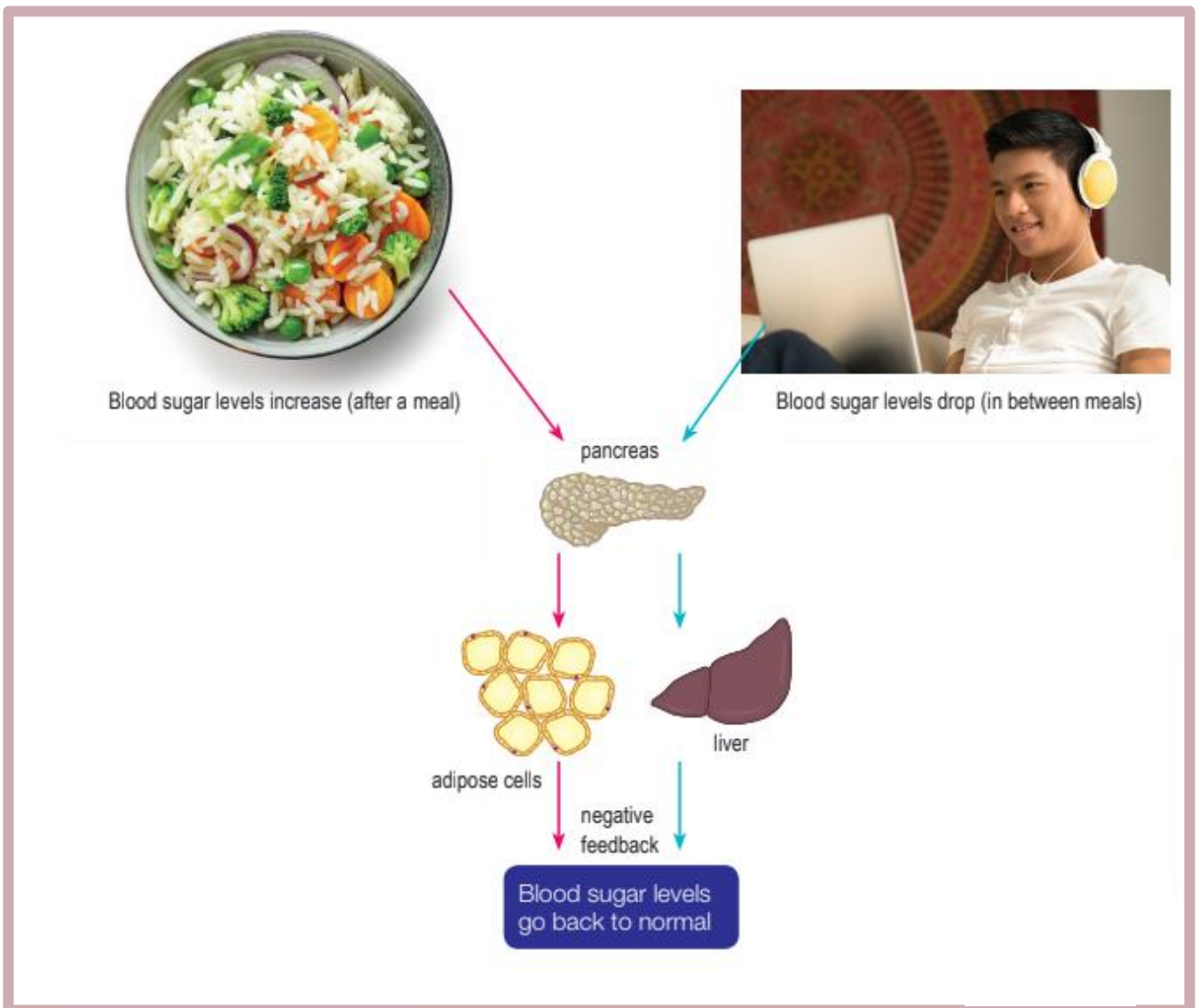
THYROID GLAND

- + The thyroid gland is stimulated to secrete more thyroxine which will increase the metabolic rate
- + More heat is generated for the body



Regulation of blood sugar levels

- ❑ The pancreas is responsible for maintaining blood sugar (glucose) levels within the normal range of 75-110 mg/100 ml
- ❑ Langerhans cells in the pancreas produce and secrete insulin and glucose continuously into the bloodstream to regulate blood sugar levels
- ❑ The action of both these hormones and the mechanism of homeostasis work together to maintain the blood sugar levels within the normal range
- ❑ Failure in the production, secretion and intake of insulin by target cells can cause diabetes mellitus
- ❑ The blood sugar level of diabetic patients is usually high and unstable after a meal
- ❑ The patient also feels thirsty, tired, fatigued and suffers weight loss
- ❑ Diabetes mellitus can be controlled through insulin injections, pills that lower blood sugar levels and a proper diet



BETA (β) CELLS (after a meal)

- ♥ Beta (β) cells in pancreatic Langerhans cells are stimulated to secrete insulin into the blood
 - a. Insulin stimulates the muscle cells to use glucose in the process of cell respiration
 - b. Insulin stimulates the conversion of excess glucose into glycogen to be stored in the liver and muscle cells
 - c. In adipose cells, insulin converts excess glucose to fat

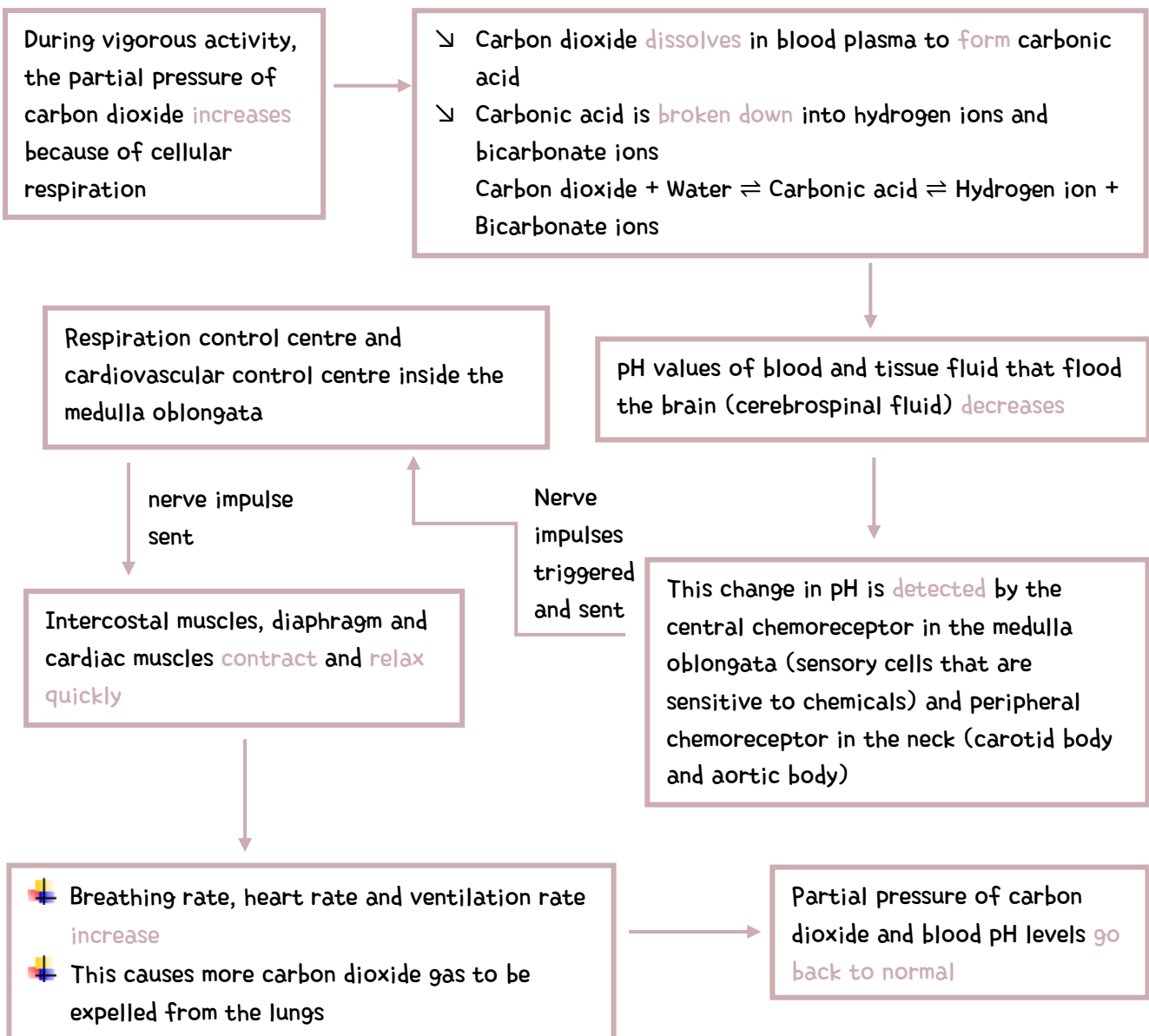
ALPHA (α) CELLS (in between meals)

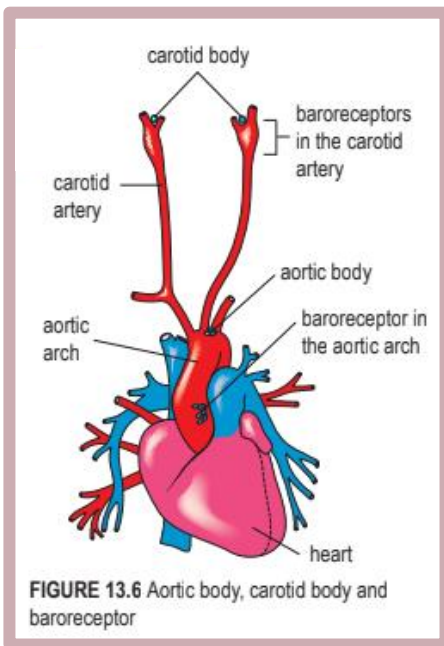
- Alpha (α) cells in pancreatic Langerhans cells are stimulated to secrete glucagon in to blood
 1. Glucagon stimulates liver cells to convert glycogen to glucose
 2. Glucagon also promotes the breakdown of fat to release fatty acids that can be metabolised to produce energy

Regulation of partial pressure of carbon dioxide in the blood

- » Breathing is an involuntary action that is regulated by the respiratory control centre in the medulla oblongata
- » The respiratory control centre helps maintain homeostasis by controlling the partial pressure of carbon dioxide in the blood

PROCESS OF REGULATING PARTIAL PRESSURE OF CARBON DIOXIDE IN THE BLOOD

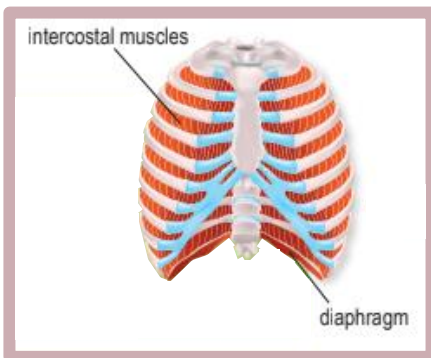
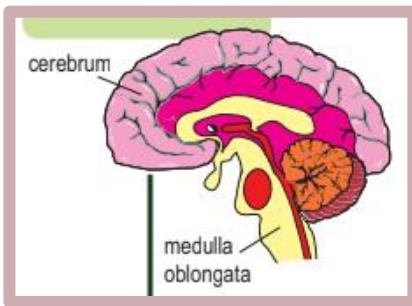




Δ These receptors detect the pressure of blood flowing through them and continuously send impulses to the cardiovascular control centre in the medulla oblongata to regulate blood pressure

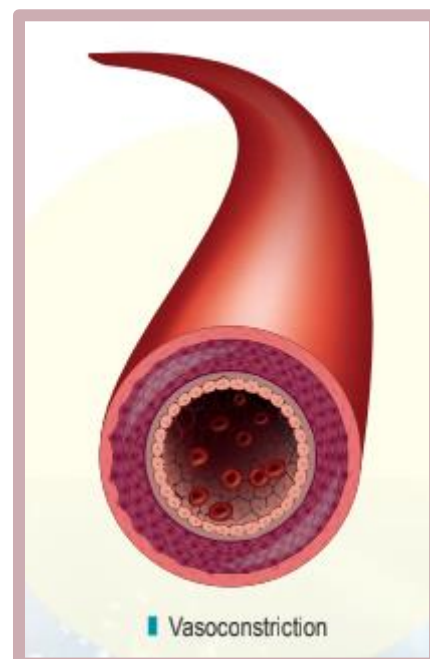
VASOCONSTRICTION

- ↪ When an individual's blood pressure drops, for example, if there is serious bleeding
- ↪ Baroreceptors in the aortic arch and carotid artery are less stimulated
- ↪ The cardiovascular control centre in the medulla oblongata is less stimulated
- ↪ Then, arterial vasoconstriction occurs
- ↪ This adds resistance to the flow of blood in the bloodstream
- ↪ After that, stronger contractions of cardiac muscles occur
- ↪ In the meantime, blood pressure increases
- ↪ Lastly, blood pressure returns to the normal ranges



Blood pressure regulation mechanism

- Δ Baroreceptors or pressure receptors are located in the aortic arch and carotid artery
- Δ The carotid artery is the artery in the neck that supplies blood to the head



VASODILATION

- ✚ When an individual's blood pressure increases, for example during vigorous activities
- ✚ Baroreceptors in the aortic arch and carotid artery are stimulated
- ✚ The cardiovascular control centre in the medulla oblongata is stimulated
- ✚ Then, vasodilation occurs
- ✚ This reduces the resistance of the flow of blood in the bloodstream
- ✚ After that, weak contractions of cardiac muscles occur
- ✚ In the meantime, blood pressure drops

- ✚ Lastly, blood pressure returns to the normal ranges



CHAPTER 13.2 – URINARY SYSTEM

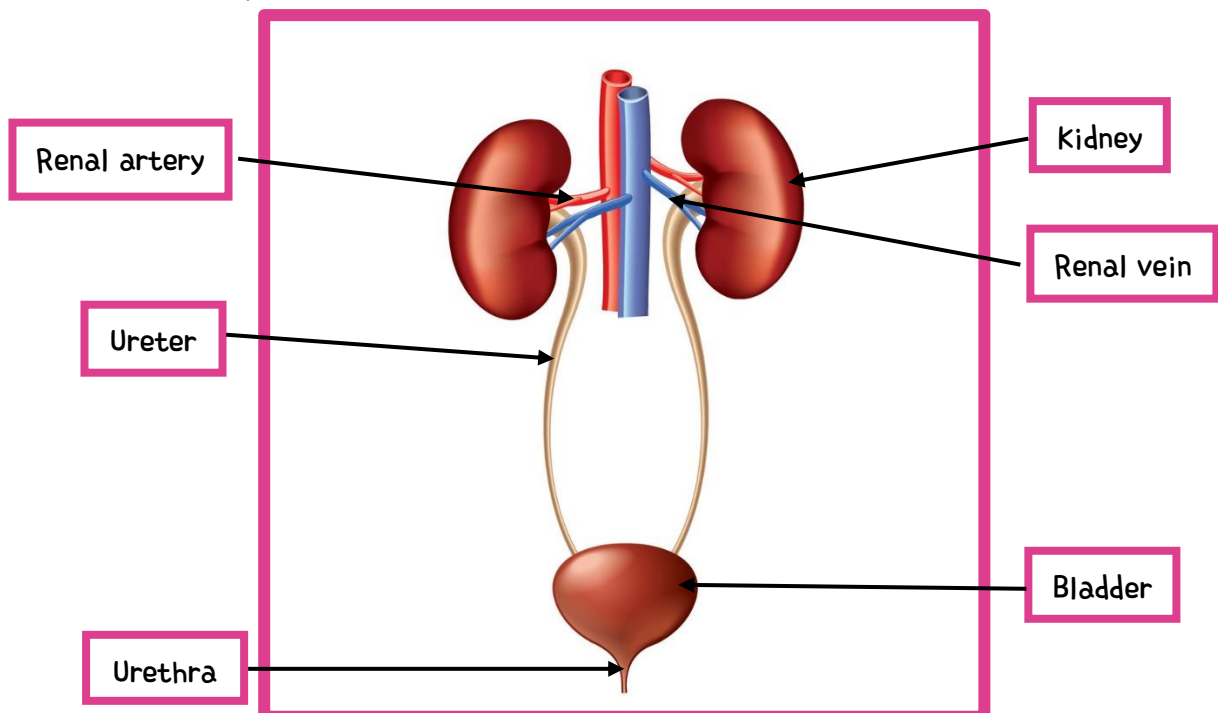
Urinary system

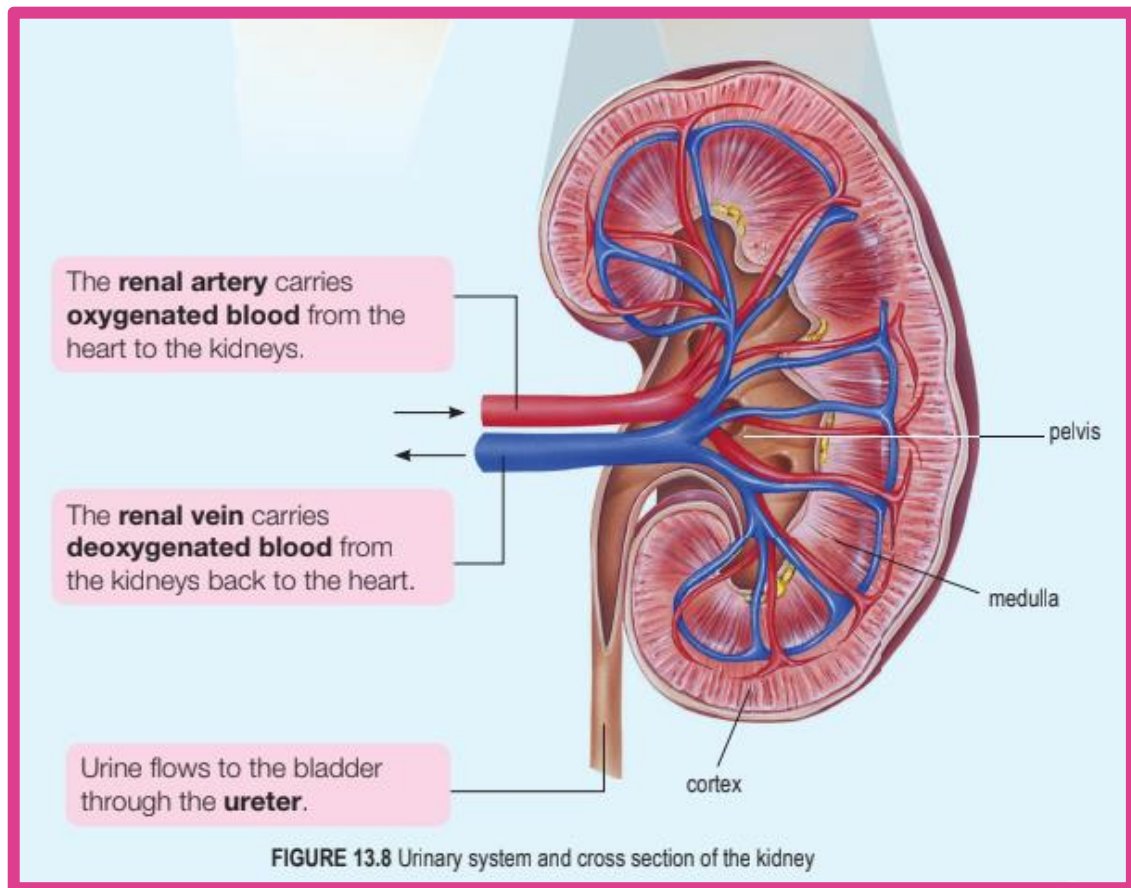
- ↳ The human urinary system plays an important role in homeostasis
- ↳ The urinary system is **made up** of the **kidneys, ureters, bladder and urethra**
- ↳ The function of the urinary system is to **excrete nitrogenous compound wastes** such as **urea**, as well as **regulate the volume of the body fluids, blood osmotic pressure, ion concentration in body fluids, electrolyte content and blood pH**

Structure and function of the kidneys

- ⊕ The kidneys consist of the cortex and medulla
- ⊕ Urine that is formed in the kidneys flows into the pelvis

- ⊕ The kidneys have **two** main functions:
 - ◇ Excretion
 - ◇ Osmoregulation
- ⊕ As an excretory organ, the kidneys **excrete toxic wastes** (nitrogenous compounds) such as **urea, uric acid, ammonia and creatinine**
- ⊕ As an osmoregulatory organ, the kidneys control:
 - The total volume of water in body fluids
 - The concentration of ions in body fluids
 - Blood osmotic pressure, which is the concentration of dissolved materials and volume of blood and body fluids
 - Electrolyte content and pH of blood and body fluids



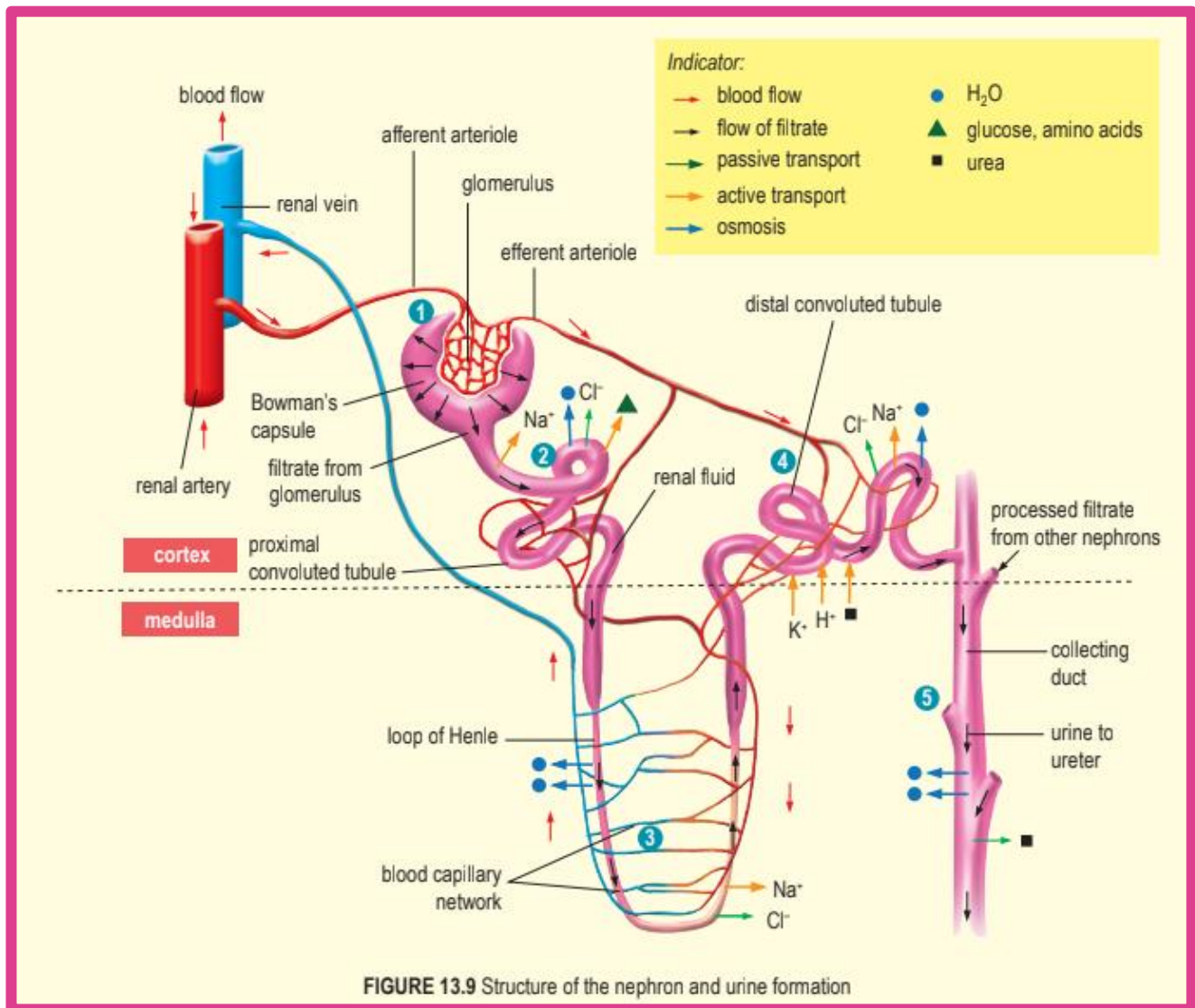


Formation of urine

- There are **three major processes** involved in the production of urine, which are **ultrafiltration**, **reabsorption** and **secretion**

NEPHRON

- ❖ Each kidney is made up of **millions of functional units** called **nephrons**
- ❖ Each nephron is made up of the following structures:
 - i) Bowman's capsule
 - ii) Glomerulus
 - iii) Renal tube
- ❖ **Bowman's capsule** is **cup-shaped** and **contains** a cluster of blood capillaries called **glomerulus**
- ❖ The **glomerulus** is **formed** from the **afferent arteriole** branching from the renal artery
- ❖ The **glomerulus** **merge** again to **form** the **efferent arteriole**
- ❖ The renal tubules are **composed** of the **proximal convoluted tubules**, **loop of Henle** and **distal convoluted tubule**
- ❖ The **loop of Henle** is a **long U-shaped tubule** that extends to the renal medulla
- ❖ The **distal convoluted tubule** of several nephrons **join together** into a **collecting duct**
- ❖ The produced urine will flow from the collecting duct into the ureter



1 ULTRAFILTRATION IN BOWMAN'S CAPSULE

- ◇ Blood entering the glomerulus is under high **hydrostatic** pressure because the diameter of the afferent arteriole is **larger** than the diameter of the efferent arteriole
- ◇ This pressure causes **ultrafiltration to occur**, that is, fluid seeps through the walls of the glomerulus capillaries into the cavity of Bowman's capsule
- ◇ The fluid that enters Bowman's capsule is known as the **glomerular filtrate**
- ◇ The glomerular filtrate has the **same composition** as blood plasma but does **not contain** red blood cells, platelets and plasma protein
- ◇ Red blood cells and plasma proteins remain in the blood flowing to the efferent arteriole because the size of these substances is **too large** to seep out of the glomerulus

2 REABSORPTION AT THE PROXIMAL

CONVOLUTED TUBULES

- ↳ **Reabsorption** of the glomerular filtrate occurs along the renal tubule
- ↳ The dissolved substances permeate across the renal tubular walls into the blood capillary network
- ↳ In the proximal convoluted tubule, sodium ions (Na^+) are actively pumped into the blood capillary network and chloride ions (Cl^-) are **passively absorbed**
- ↳ The reabsorption of 100% glucose and amino acids also occurs through **active transport**
- ↳ The movement of dissolved substances into the blood capillary network reduces the concentration of dissolved substances in the glomerular filtrate but increases the concentration of dissolved substances in the blood capillaries
- ↳ As a result, water enters the blood capillaries through osmosis

3 REABSORPTION AT THE LOOP OF HENLE AND DISTAL CONVOLUTED TUBULES

- △ In the loop of Henle, water is reabsorbed through osmosis
- △ Sodium ions are reabsorbed through **active transport**
- △ In distal convoluted tubules, more water, sodium and chloride ions are reabsorbed
- △ The amount of water and salts reabsorbed depends on the water and salt content in the blood

4 SECRETION

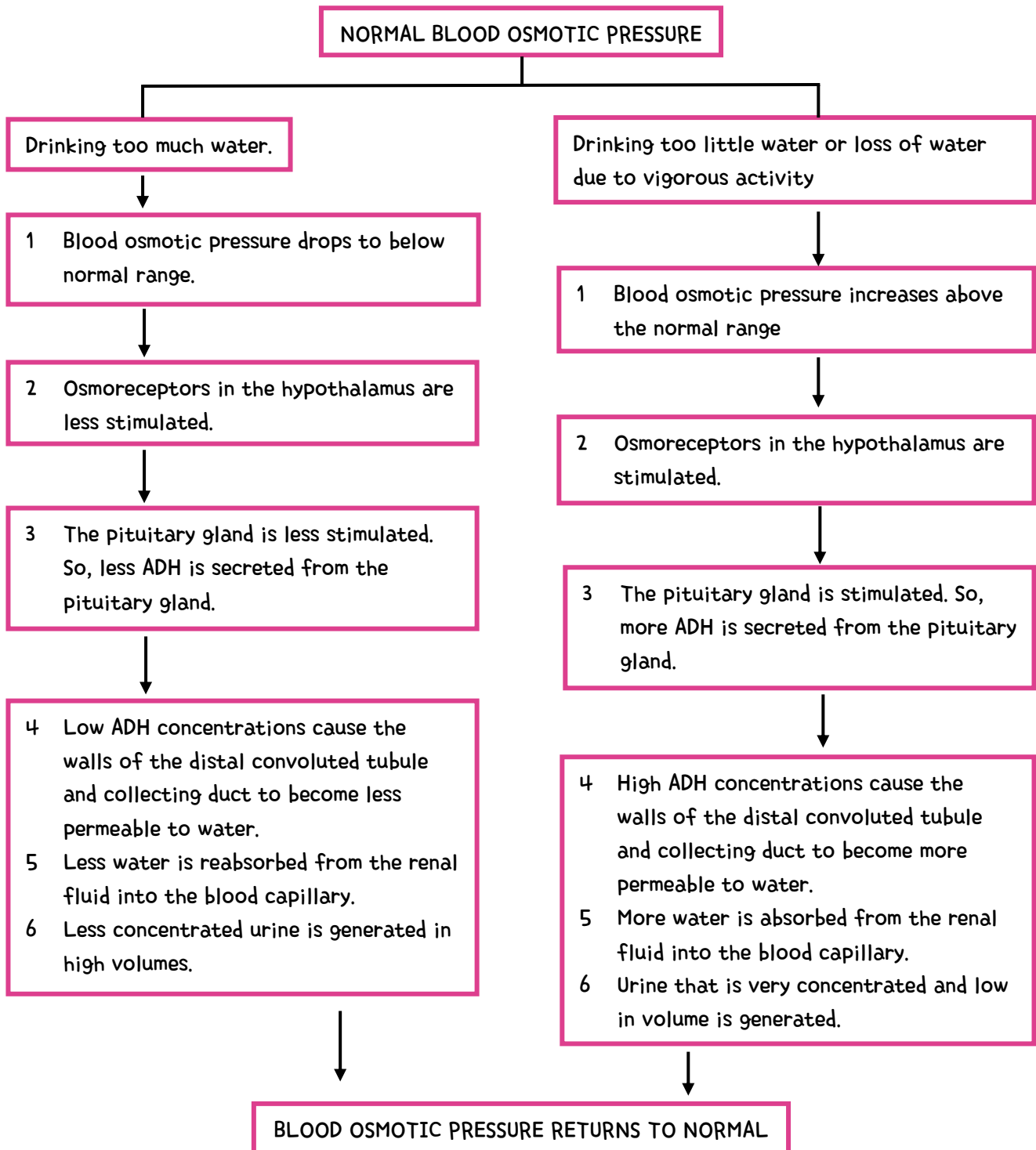
- » **Secretion** is the process of secreting waste materials in the blood that were not filtered earlier into the renal tubules
- » This process is opposite to the process of reabsorption
- » Secretion occurs along the renal tubule and collecting duct, but it is most active at the distal convoluted tubule
- » Secretion occurs through simple **diffusion** and **active transport**
- » Substances that are secreted include hydrogen ions (H^+), potassium ions (K^+), ammonium ions (NH_4^+), urea, creatinine, toxic substances and some drugs
- » Secretion gets rid of toxic wastes and helps to regulate the levels of ions in the blood

5 URINE FORMATION

- ⊞ When the renal fluid reaches the collecting duct, only a small amount of salts are left, and most of the water has been absorbed back into the bloodstream
- ⊞ The remaining renal fluid is now called **urine**, flows down the collecting duct
- ⊞ Here, a small amount of urea diffuses out into the surrounding fluid and blood capillaries due to its small molecular size
- ⊞ Urine contains water, urea, NaCl salt, uric acid and creatinine
- ⊞ After leaving the collecting duct, urine flows through the ureter, bladder, urethra, and is finally excreted

Mechanism of homeostasis and osmoregulation

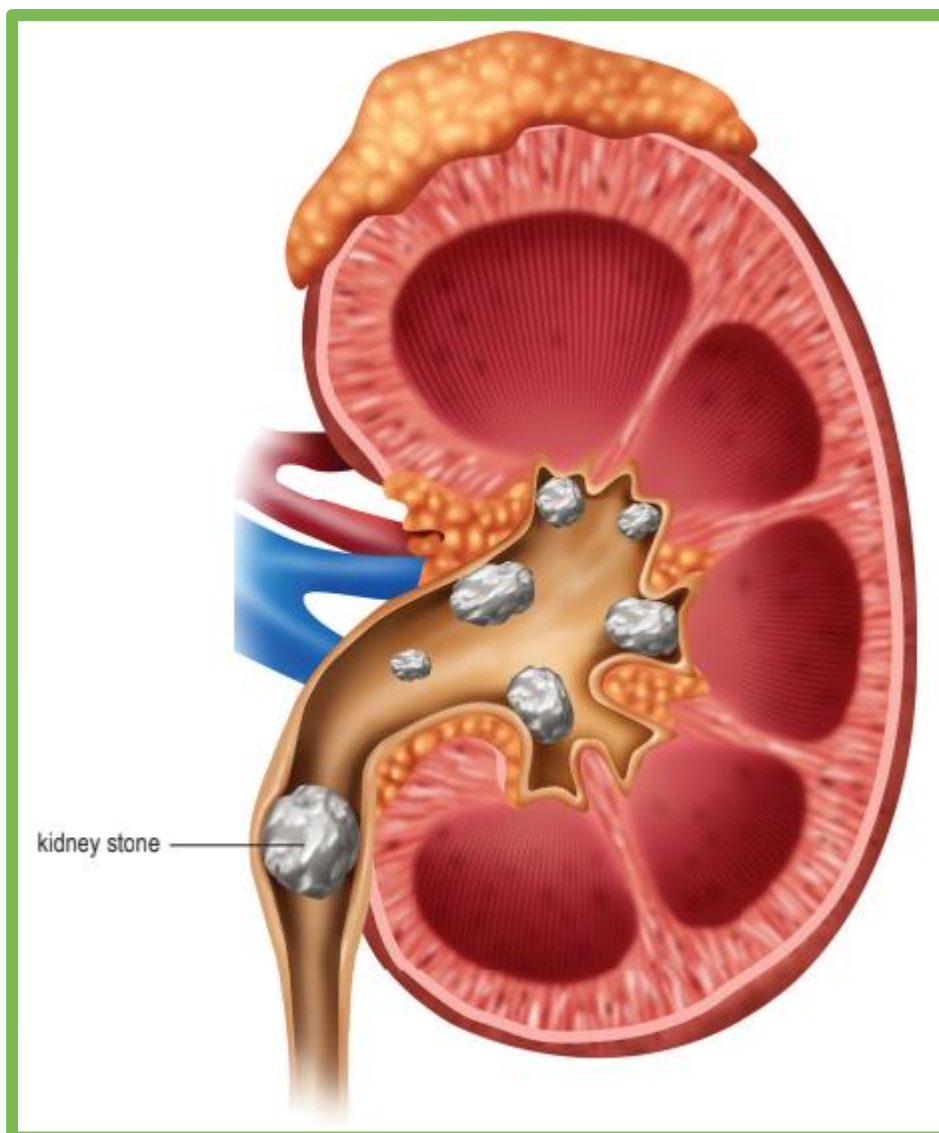
- The body's water content constantly changes depending on the intake of food and drinks
- Osmoregulation is the process of regulating water and salts in the body so that the blood osmotic pressure can be maintained at a normal range
- Osmoregulation is achieved by regulating the volume of urine produced by the kidney



CHAPTER 13.3 – HEALTH ISSUES RELATED TO THE URINARY SYSTEM

Health issues related to the urinary system

- Diabetes Mellitus is the leading cause of renal failure, followed by high blood pressure
- Both these conditions damage the glomerulus
- Kidney stones are hard masses made of uric acid, calcium oxalate or crystalline calcium phosphate
- Kidney stones can block the ureter and reduce the production of urine
- To reduce the likelihood of kidney stone formation, drink a lot of water every day





Summary

